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AN EPIDEMIOLOGIC INVESTIGATION OF OCCUPATION, AGE, AND EXPOSURE--ETC(U)
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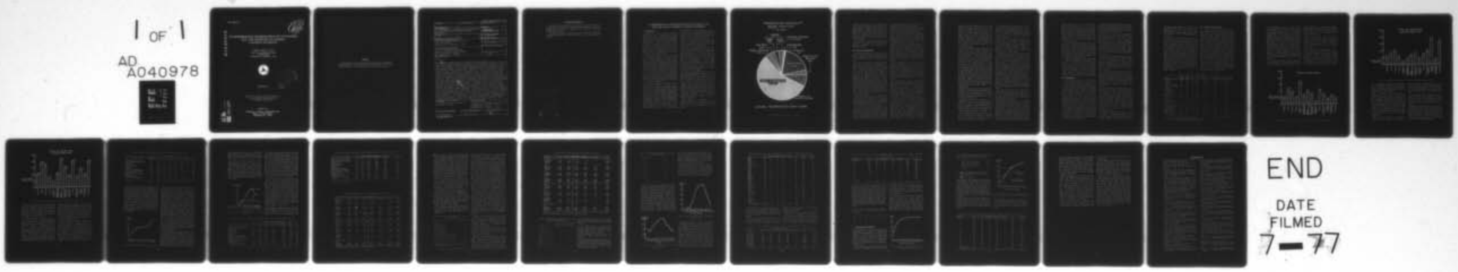

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AN EPIDEMIOLOGIC INVESTIGATION OF OCCUPATION, AGE, AND EXPOSURE IN GENERAL AVIATION ACCIDENTS

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16. Abstract This study involved a census of 4,491 general aviation accident-involved airmen records for the year 1974 to obtain relevant occupation, age, exposure, and other epidemiologic profile information of a descriptive nature. Population comparison data for occupation, age, and exposure were obtained from a sample of 9,414 currently certified airmen medical records as of December 1974. Occupation was studied under assumptions of similar exposure, total cumulative exposure by occupation, and recent exposure by occupation with the outcome under at least two methods of analysis being the identification of physicians, lawyers, sales representatives, farmers, and housewives as having high accident experience. Whether considering cumulative or recent exposure, high exposure is associated with the highest risk when considered separately and when combined with the younger ages. Recent exposure appears to be more important as a risk factor. The months of April through September are peak accident months. Alaska, Arkansas, Idaho, Nevada, New Mexico, West Virginia, and Wyoming all had at least double the accident experience expected. Eighty-five percent of all accidents occurred between 9 o'clock in the morning and 9 o'clock in the evening. More than half (55 percent) of all accidents occurred within 1 hour after takeoff. Sixty percent of accident flights were originated for pleasure purposes. Fewer than expected accident-involved airmen had limitations and 75 percent had a medical examination within a year prior to the accident.

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AN EPIDEMIOLOGIC INVESTIGATION OF OCCUPATION, AGE, AND EXPOSURE IN GENERAL AVIATION ACCIDENTS

I. Introduction

Accidents as a cause of disability and death represent an area of increasing public health concern, and an area deserving of considerably more attention in future public health planning. When all ages are considered, accidents currently rank fourth as a cause of death, after cardiovascular disease, malignancies, and cerebrovascular disease. Accidents represent the leading cause of death for younger age groups. Tremendous losses are incurred in terms of permanent disability, disfigurement, and economic productivity for accident survivors.

Transportation accidents have historically made a major contribution to overall accident morbidity and mortality. According to preliminary estimates published by the National Transportation Safety Board in May 1976, 49,502 fatalities occurred in transportation accidents of all types during 1975. Highway accidents, which include automobile, truck, pedestrian, motorcycle, and bicycle accidents, are, of course, the major cause of transportation fatalities. Following highway accidents, in terms of magnitude, are marine accidents and general aviation accidents. Grade crossing, railroad, air carrier, and pipeline accidents comprise the remainder of transportation accidents[1] (see Figure 1).

The primary mission of the Federal Aviation Administration (FAA) is air safety. Consequently, the agency devotes considerable effort to control of the aviation environment, including commercial and general aviation equipment testing, inspection, and maintenance; qualifications of airmen as relates to both competency and medical aspects; and air traffic control equipment and manpower. Research and development are of continuing concern to the FAA in furthering administration objectives with respect to air safety in those areas described. Much of this research effort has been concerned with environmental hardware factors (i.e., better equipment and facilities) or with human factors aspects of crash survival. Very little attention has been devoted to classical epidemiologic methods and variables as an approach to a better understanding of the etiology of aircraft accidents.

Much of the available research has been conducted in a military setting on a group that might be considered unique with respect to population characteristics and equipment.

Interest has been apparent in recent years concerning the possible importance of occupation as a risk factor in general aviation accidents. The various rationales for such interest include the personality traits likely possessed by persons in certain occupational categories; e.g., physicians and executives are usually characterized as being aggressive and independent. Another variable of obvious importance involves amount and type of exposure to the aviation environment. Historically, this has been a rather elusive factor for a number of reasons, ranging from definition to accuracy of data for analysis.

The FAA is continually searching for risk factors or categories of airmen likely to represent higher accident proneness. The mechanisms for airmen education are well established and have been quite effective in reducing risk of accident once a factor is realized, documented, and brought to the attention of the proper authority.

General aviation has experienced substantial growth during the past decade. Given that occupation and the economic feasibility of general aviation as a means of transportation are so obviously related to exposure, these factors appear to represent important areas to consider in achieving a better understanding of the epidemiology of accidents.

From a public health standpoint as well as from the FAA mission standpoint, it is appropriate to consider these rather obvious factors in an attempt to identify potential higher risk groups.

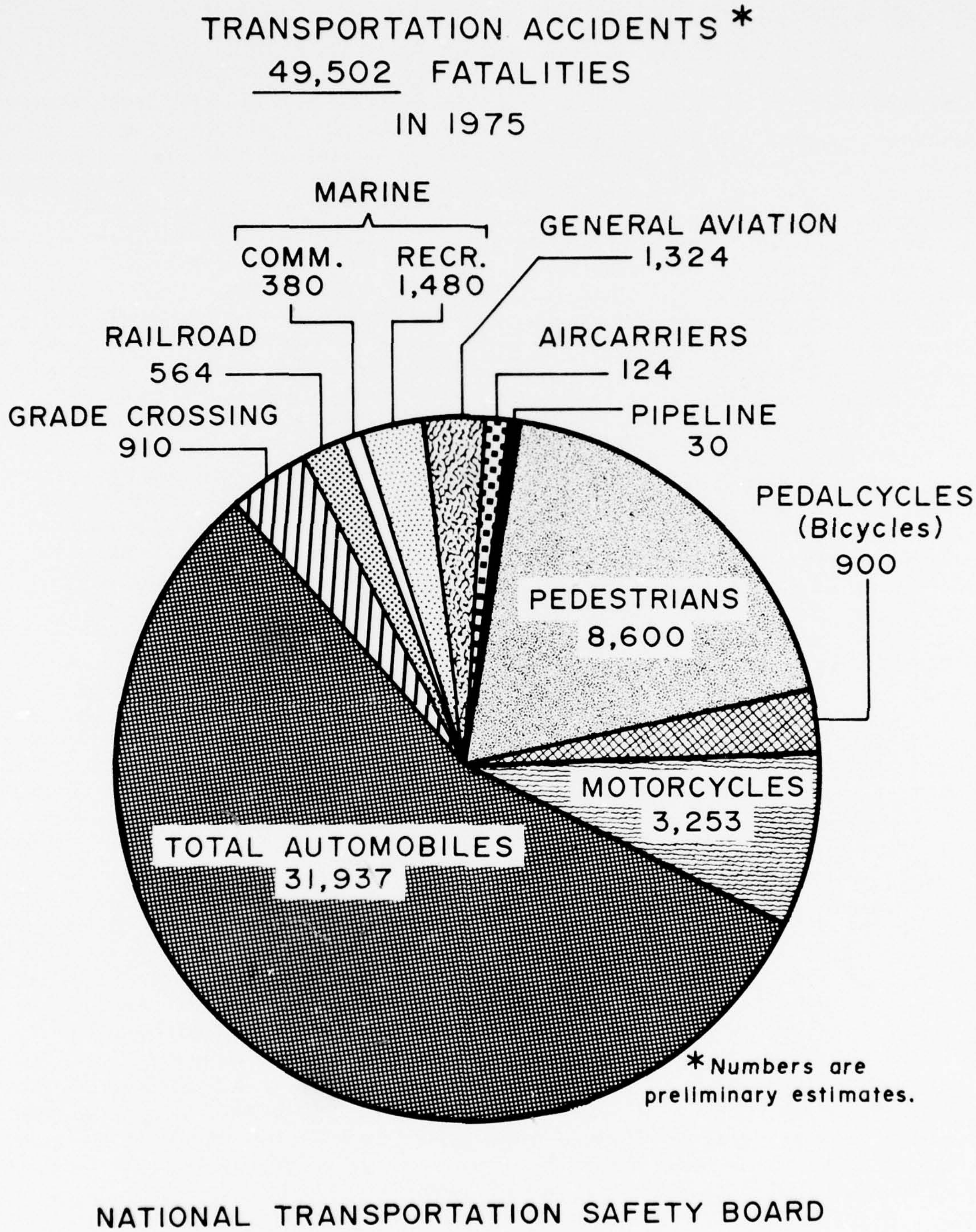

FIGURE 1.—Distribution of transportation fatalities

This study compares accident experience for various major occupational groups, ages, and exposure categories to appraise differences in accident experience. Population data necessary for comparison were obtained by sampling techniques. An important by-product of the study has been the establishment of a current, descriptive, epidemiologic data base that will be used in future studies.

The conclusions and descriptive findings of this study will provide the basis for further hypothesis formulation and intensification of educational efforts.

II. Historical Background

Occupation has been, and continues to be, a factor of considerable importance in understanding the etiology of various infectious and presumably noninfectious diseases that afflict modern man.

The literature provides numerous examples indicating the importance of occupation as a direct cause of disease in man. Most of the more classic examples are related to the noninfectious diseases. Early research efforts indicated the increased incidence of scrotal cancer among chimney sweeps.[2] Radiologists were found to experience more leukemia than other physicians, suggesting the effects of exposure to x-ray.[3] Workers who applied radium paint to watch dials were observed to develop bone cancer.[4] The high frequency of urinary bladder cancer among aniline dye workers and of lung cancer in miners of radioactive ores are additional examples of findings relating occupation to noninfectious disease.[5, 6] More recently, the association of various cancers with polyvinyl chloride production and use has been examined.[7]

Tuberculosis and silicosis were frequently observed among miners exposed to dusts with high silica content.[8] Less well known are the findings associating clinical laboratory personnel and other hospital personnel who must handle blood with increased risk of Type B hepatitis.[9]

Less obvious in terms of cause and effect is the association between "stress" experienced in many occupations and the development of various noninfectious and psychosomatic diseases. Air traffic control is considered a stressful occupation, and air traffic controllers have been found to experience higher-than-expected prevalence rates for hypertension, peptic ulcer, and diabetes in comparison to other airman categories.[10]

Studies done on accountants during the stressful income tax season have shown increased levels of cholesterol during this stressful period.[11]

Other studies have considered the relationship of stress presumed to result from certain occupations and the occurrence of heart disease. Available evidence suggests that occupation has considerable impact on an individual, both physiologically and psychologically.

Historical information relating occupation to accident occurrence is obvious in some cases but probably less well known to the medical community. Various occupational and industrial safety programs have recognized the greater risks associated with certain occupations involving the use of powerful and complex machinery, the handling of chemical agents, and prolonged exposure to a specific environment, such as driving.

The epidemiology of accidents is becoming increasingly important in the identification of factors that increase one's accident proneness. This area of investigation represents a specialty for the field of epidemiology much the same as infectious and noninfectious diseases and mental health have represented areas of specialization. Public health planners suggest that much greater attention will be devoted to this area in coming years.[12]

It is apparent that many of the previously mentioned occupation/morbidity/mortality relationships are more direct than others. The cause-effect relationship is easier to visualize and deal with in terms of programs for intervention for radiologists, aniline dye workers, and uranium miners, for example, than it is for noninfectious and so-called psychosomatic diseases presumed to be induced by such vague factors as "stress."

This study provides an interesting combination of direct and indirect relationships. Exposure in terms of hours flown is an obvious, rather direct factor that one can observe in terms of general aviation accident rates. However, with few exceptions, such as agricultural pilots, occupation is less obvious with regard to the exact mechanisms that might contribute to differences in accident rates. This is not the usual relationship of occupational exposure to some toxic substance that results in disease or occupational stress resulting in disease. However, personality

traits, stress of commitments, and other factors common to certain occupations may very well result in precipitous action that results in an accident. An earlier study speculates that occupation (i.e., economic ability) simply allows for greater exposure, which in turn accounts for higher accident rates among certain occupation groups.[13] Exposure to the environment is a necessary ingredient of general aviation accidents. However, it is the extent of exposure and the interaction with other variables that are being examined here.

While considerable research effort has been devoted to the areas of commercial and general aviation safety, most has been directed to improvement of the environment in terms of equipment and facilities. Very limited information exists concerning the more classical epidemiologic variables in an attempt to better understand the etiology of aircraft accidents. Zeller and his colleagues have done substantial work in a military environment on the epidemiology of accidents. In a 1953 study by Zeller and Mosely,[14] young and inexperienced pilots were found to contribute to a disproportionately large number of military jet aircraft accidents. Results of a similar study by Zeller in 1956 suggested improved accident experience for younger ages, but overall younger age groups continued to experience higher accident rates.[15] However, as previously mentioned, the equipment, age distribution, and medical criteria for Air Force pilots make comparisons with general aviation accident data difficult, if not inappropriate.

Medical factors have long been recognized as important in the epidemiology of both military and civilian aircraft accidents. For this reason, the FAA devotes considerable effort to screening prospective airmen for pathology likely to result in sudden incapacitation.

Dougherty et al. found the relative risk of accident to be 2.24 for airmen with any physical defect; the relative risk of fatal accident was 2.41, with increasing risk for multiple defects.[16] Rohde and Ross, in a 1970 contract study, considered 25 medical variables and found 7 to be associated with increased risk of accident.[17]

The contribution of suicide to general aviation accident morbidity and mortality is recognized and has been studied in a limited way because of the small number of observations.[18, 19]

Alcohol and drugs have been implicated in aircraft accidents to an alarming degree.[20-26] This experience would certainly parallel auto accident experience. In the past, alcohol has been present in up to 35 percent of fatal general aviation accidents, and a causal role has been established in about 7 percent.[26]

Several studies have dealt with accident risk related to age. Costin found an increased risk of accident with age in 1959.[27] These results were verified by Harper in 1963, Lategola et al. in 1970, and Rohde and Ross in 1970.[28, 29, 17] Mohler et al. found the higher age groups to experience no greater risk of accident than younger airmen in a 1967 study.[30]

Occupation and risk of accident has been a subject of continuing interest to the FAA and its predecessors, as well as the aviation community. Since the days of the barnstormers, wing-walkers, and daredevil stunt pilots of the early 1900's, certain very definite risks have been realized and dealt with in terms of regulations to protect the population as well as the individual pilot. Agricultural pilots have long been recognized as a group subject to increased risk of aircraft accident. Substantial improvement in morbidity and mortality among this group has been realized in recent years because of improvements in equipment. Ryan and Dougherty (1969) found that age and experience were unrelated to agricultural accidents by type of equipment.[31] Their findings involved extensive analysis of differences in morbidity and mortality by types of equipment utilized and environmental factors.

Attention has been focused on selected occupations and professions in recent years with respect to their accident experience. Mohler et al. in a much publicized 1966 report indicated that physicians have four times the accident rate of other general aviation pilots.[32]

Wick has done considerable work in analyzing the relationship of aircraft accidents to occupations. In his 1966 study, he makes some pertinent observations concerning this relationship. Wick considers exposure and personality traits reflected by some professions and occupation groups to be important in the etiology of aircraft accidents, with the greater emphasis on exposure. Physicians, executives, salesmen, farmers, and ranchers were found to have higher accident experience, both fatal and nonfatal, than expected

while housewives and teachers were found to experience fewer accidents than expected. Wick suggests that certain occupations are economically more capable of flying than other groups and that this is an important consideration because of the greater exposure alone.[13] In a later study dealing with physician pilots, Wick documents a considerably greater exposure factor for physicians versus other general aviation pilots based on a sample.[33]

A recognized difficulty in all the studies cited has been the availability of appropriate and accurate denominator data for rate computation. Numerator data are easy to acquire from existing accident files. Occupation and professions listed on accident reports are, of course, subject to similar bias type errors normally associated with such studies; i.e., the tendency to upgrade one's occupation for reporting purposes.

Exposure also represents an area of difficulty in regard to availability of population data. What is the relevant measure of exposure? Should it be hours flown, number of takeoffs and landings, type of aircraft, or some other indicator? Difficulties exist with each measure.

This study represents an effort to bring together occupation, age, exposure, and other descriptive data on a scale of analysis never before available in order to appraise the relationships.

III. Methodology

A. *General Description of the Research Design.* This analytic, epidemiologic study involved a census of general aviation accidents for the year 1974 to obtain relevant occupation, exposure, and other epidemiologic profile information of a descriptive nature. Population comparison data for occupation and exposure were obtained from available current records under multinomial sampling techniques and subsequent extrapolation to the total population. The approach was retrospective in that accident and population information were researched for pertinent information after the outcome had been realized; i.e., given the outcome, the research involved categorizing accident-involved airmen by occupational and exposure groups as opposed to the prospective approach wherein the occupation groups are identified and followed to see what the accident experience was over a certain period of time. A hypothesis of "no difference" was tested for accident experience among various occupation/exposure categories.

Certain other epidemiologic information was obtained primarily for descriptive purposes and to provide current profile information in anticipation of the formulation of other hypothesis for testing based on current data.

B. *Population Studied.* The 1974 general aviation medical accident files maintained by the FAA represented the "cases" studied. The number of such cases was 4,491. A sample of 9,414 was taken from the active airman population medical tape files as of December 31, 1974, for purposes of estimating the population occupation and exposure characteristics. There were 762,604 airmen currently medically certified at that time (having been medically certified within the 2 preceding years as prescribed by regulations).

The population sampling problem in this study amounted to an estimation of population parameters for 15 major occupation groups. These occupation groups are based on Bureau of the Census classifications with some modification and additions. Sample design and size assure a useable error for the smaller proportions expected for some groups.

Accident files are arranged in numeric sequence by date of receipt. No bias was anticipated because a census of accident records was performed. Population records are maintained by alphabetic sequence, and a sample was drawn from these records for estimation purposes. The alphabetic sequence is not expected to introduce bias among the sample for variables being analyzed.

Rate computations and extrapolations to the population from sample results were based on the December 31, 1973, population of 758,243 active airmen; i.e., those airmen medically certified within the preceding 24 calendar months. The December 1973 population was used because it approximates the midpoint of the accident group. Individuals having accidents in 1974 would have received medical certification after January 1972 if they were currently certified at the time of the accident. The population midpoint likewise encompasses a group certified after January 1972.

A midpoint population is desirable for rate computations. The airman population is growing, and use of a population total at either time extreme would bias results somewhat. Numer-

ator data (accident airmen) are constant; therefore, higher rates would result if an earlier population total was used (i.e., 1972) because the denominator would be smaller. The opposite bias would occur if the 1974 population total were used.

Occupation was obtained from entries by the airman on the hard-copy application form and was later coded according to Bureau of the Census occupational codes. Traditional problems associated with overstatement of occupation were experienced. Problem cases were resolved by study team decision. Some problems are recognized with respect to accuracy of flight time data. Airmen with low flight time are likely to know and record their flight time more accurately than are airmen with high flight time, who may tend to round off their responses. Since there are many more airmen in the lower categories, the impact on this study is felt to be minimal. Further, much of the analysis to follow makes use of rather broad intervals for higher flight time groups where accuracy is expected to depreciate.

IV. Results and Discussion

A. *Accident Experience by Occupation.* Professional and technical occupations, farmers and farm managers, and service workers (mainly protective service workers) had the highest occupation-specific rates among the major occupational categories (Table 1). These three categories exceeded the overall crude accident rate of 5.9 per 1,000 for the population. All other major occupational categories had rates of less than 5.9 per 1,000 (with the exception of the farm laborers, whose number was so small as to make results questionable, and these are thus eliminated from further discussion). Accident experience of the professional and technical category and the farmers and farm managers category significantly exceeded expectations (this and all subsequent statements of significance are at the 0.05 level or less) whereas service workers exceeded expectations only slightly. The accident experience of all other major occupational categories was less than expected and significantly less for clerical workers, craftsmen, general laborers, housewives, and students.

TABLE 1.—General aviation accident experience by occupation—1974

Occupation	Observed Accident Frequency	Expected Accident Frequency	Ratio of O/E	X^2 Values*	Occupation Specific Rates (per 1,000)	Rate per 100,000 hours of Total Flight Time	Rate per 100,000 hours of Recent Flight Time
ALL PROFESSIONAL AND TECHNICAL	2,019	1,458	1.4	321.1	8.2	0.3	8.2
Engineers	125	156	0.8	6.4	4.7	1.1	18.9
Lawyers	57	31	1.8	23.2	11.0	1.5	36.6
Physicians	76	52	1.5	11.8	8.7	1.8	33.1
Teachers	43	60	0.7	4.9	4.2	1.1	13.3
Professional Pilots	1,302	485	2.7	1554.1	15.9	0.2	6.3
ALL MANAGERS AND ADMINISTRATORS	643	669	0.9	1.2	5.7	0.7	19.2
Managers and Administrators-General	552	542	1.0	0.2	6.0	0.7	19.2
ALL SALES WORKERS	255	272	0.9	1.1	5.6	0.7	26.5
Sales Representatives	137	90	1.5	25.6	9.0	1.2	40.7
ALL CLERICAL WORKERS	63	102	0.6	15.7	3.6	1.3	30.8
ALL CRAFTSMEN	460	774	0.6	155.0	3.5	1.1	24.6
Mechanics and Repairmen-General	44	38	1.2	1.1	6.9	1.5	28.5
Members of the Armed Forces	111	415	0.3	246.4	1.6	0.7	15.8
ALL OPERATIVES	101	115	0.9	1.9	5.2	1.4	43.9
ALL LABORERS, EXCEPT FARM	54	72	0.8	4.6	4.4	1.7	29.6
ALL FARMERS AND FARM MANAGERS	167	100	1.7	46.7	9.9	1.3	36.9
Farmers	166	97	1.7	49.8	10.1	1.3	37.9
ALL FARM LABORERS AND FOREMEN	3	1	3.0	1.7	12.4	2.2	248.3
ALL SERVICE WORKERS	94	88	1.1	0.4	6.3	2.0	21.0
Policemen and Detectives	48	43	1.1	0.6	6.6	1.8	13.8
GOVERNMENT EMPLOYEES (nec)	12	20	0.6	2.9	3.6	0.6	16.5
HOUSEWIVES	29	47	0.6	6.8	3.7	3.2	37.6
STUDENTS (ACADEMIC)	188	348	0.5	80.4	3.2	3.7	25.9
RETIRED, NONE, OR UNKNOWN	403	423	0.9	1.1	5.6	0.5	16.9
TOTAL (Crude Rates)	4,491				5.9	0.5	12.6

*Values less than 3.84 are not significant at probability level 0.05
Values equal to or greater than 3.84 are significant at probability level 0.05
Values equal to or greater than 6.64 are significant at probability level 0.01
Values equal to or greater than 10.83 are significant at probability level 0.001

While estimates were made for all occupational classifications within the major occupation categories, some results were numerically so small that further analysis was considered inappropriate. Analysis was performed in all instances where an occupational classification contained approximately 1 percent of the accident group. This criteria identified 11 specific occupations in addition to the major occupational categories. These 11 occupations plus the students and retired, none, or unknown categories accounted for 72 percent of all accidents.

Among the professional and technical occupations, the accident experience of lawyers, physicians, and professional pilots was significantly greater than expected. Engineers and teachers had significantly fewer accidents than expected.

The accident experience of sales representatives and farmers was significantly greater than expected. Consistent with expectations was the accident experience of managers and administrators, mechanics and repairmen, and policemen and detectives. Current and former members of the armed forces had significantly fewer accidents than expected.

B. *Accident Experience by Occupation and Exposure.* The preceding discussion considered accident experience based solely on proportional expectations and holds exposure constant, or assumes similar exposure, for the several categories. Empirically, this is not a realistic assumption.

When rates were computed on the basis of total hours flown (as recorded by the airman on his most recent medical examination), the major occupational categories of academic students, housewives, and service workers experienced the highest rates per 100,000 hours of total cumulative exposure, their rates being four to seven times greater than the total population experience. Students, housewives, policemen and detec-

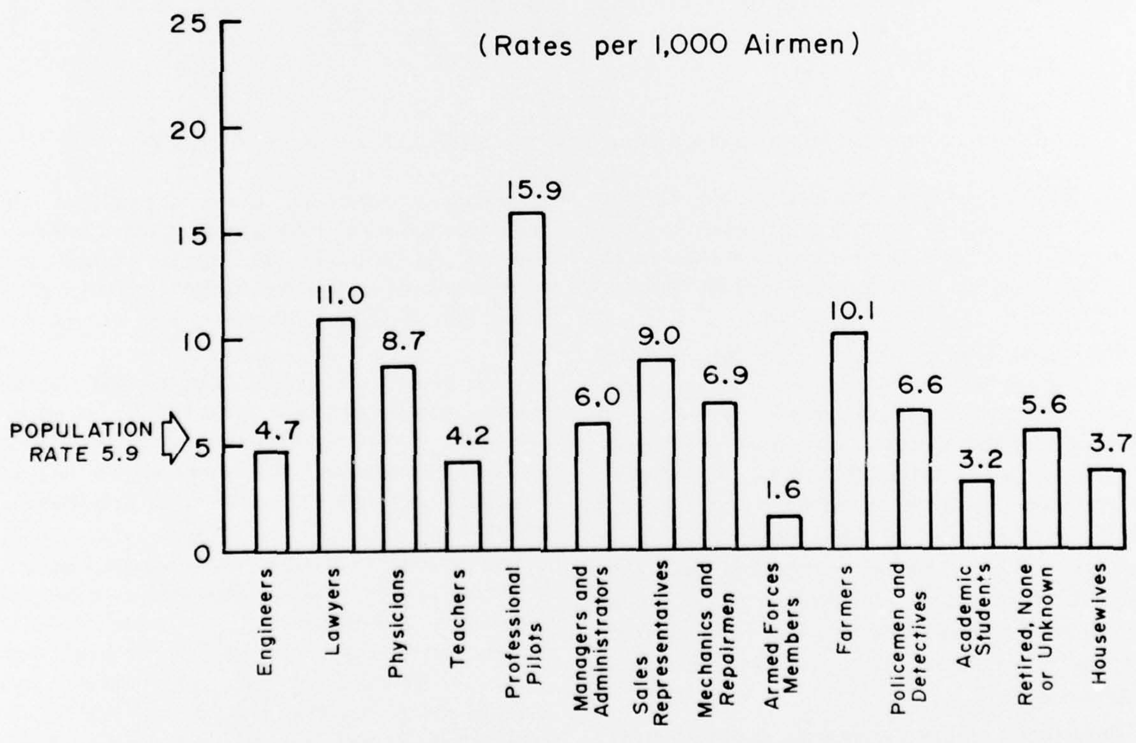

FIGURE 2.—General aviation accident rates—1974, selected occupations, cumulative flight time

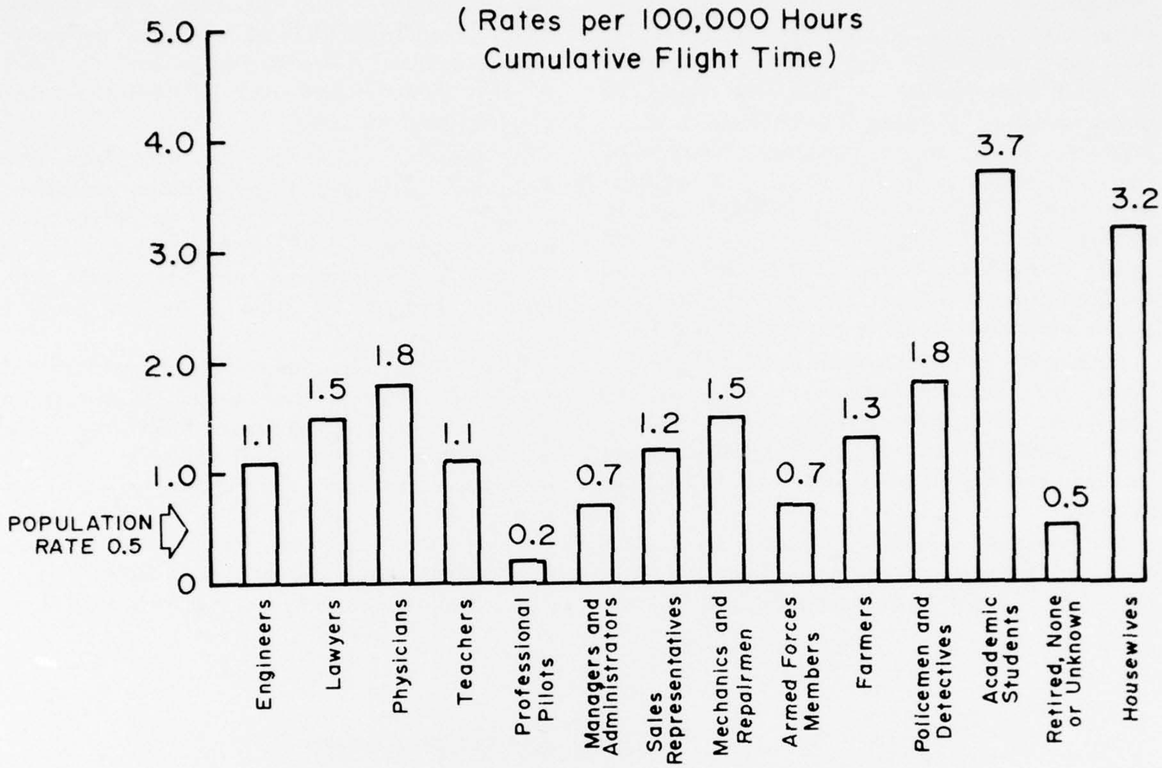

FIGURE 3.—General aviation accident rates—1974, selected occupations, cumulative flight time

tives, and physicians experienced the highest rates for specific occupational classifications based on cumulative experience, their rates being three and one-half to seven times higher than the experience of the total population.

Rates per 100,000 hours of recent exposure were highest for the major occupational categories of operatives, housewives, farmers and farm managers, clerical, and general laborers. The professional category had the lowest rate of any major category based on recent exposure (influenced largely by the professional pilot group). When specific occupations are considered, sales representatives, farmers, housewives, lawyers, and physicians had rates approximately three times the rate for the total population.

Regardless of the hypothesis concerning exposure (i.e., held constant, based on total experience, or based on recent experience) the major occupational categories of general laborers, farmers and farm managers, service workers, and housewives were identified as having higher rates under two of three measures of accident experience.

With respect to specific occupational classifications, physicians were identified by all three measures. Lawyers, sales representatives, farmers, and housewives were identified on two of the three measures as having high accident experience.

The persons involved in these occupations are, in general, likely to share some rather important personality and other traits. All are likely to be aggressive, busy, independent, and self-sufficient, accustomed to making important and weighty decisions, and also accustomed to depending on others to perform more mundane chores (such as preflight inspection).

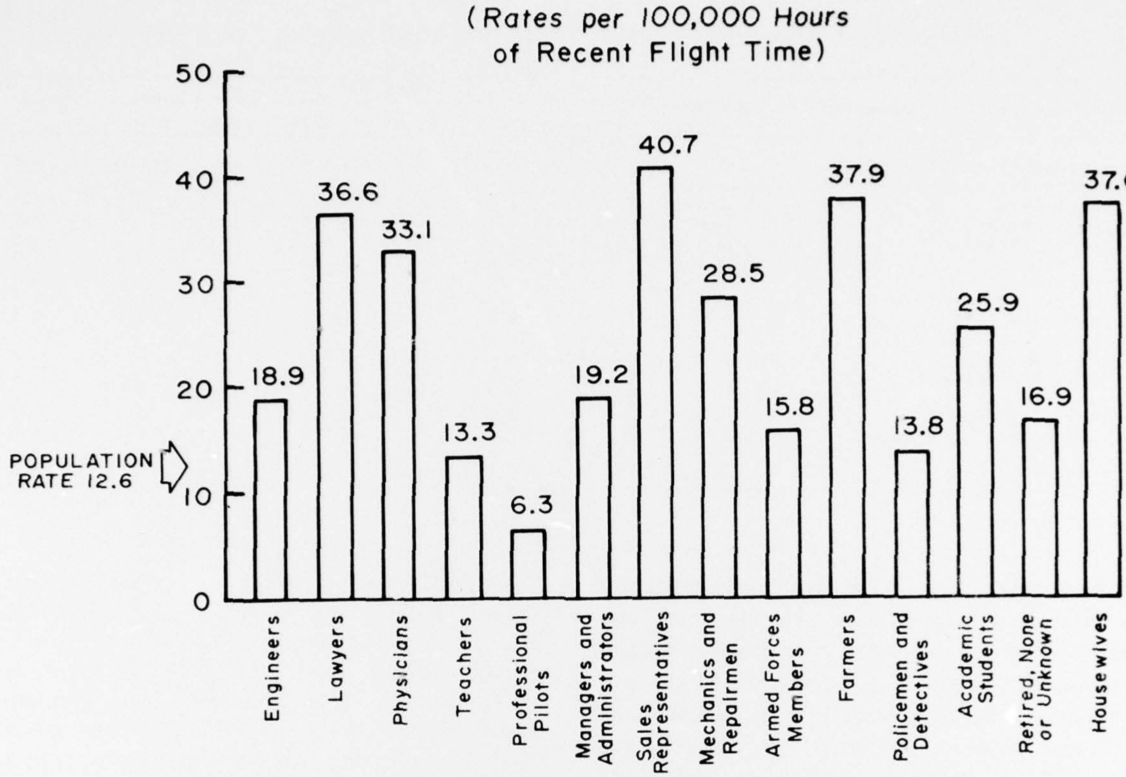

FIGURE 4.—General aviation accident rates—1974, selected occupations, *recent flight time*

Leisure time is probably at a premium among these individuals, and pressing business commitments are a frequent occurence in an already overcrowded schedule. When these factors are combined with the personality traits previously mentioned, it is easy to imagine the mechanisms for increased accident proneness.

C. *Accident Experience by Major Occupational Category and Age.* Another variable of interest with respect to general aviation accidents has been age. Several studies have demonstrated an increase in accident rates with age.[17, 27, 28, 29] Table 2 provides age/major occupational category-specific rates. The trend of the total age-specific rates shows an increase with age of approximately four times from the youngest to the oldest age intervals. The experience within the major occupational categories is generally supportive of this pattern with some dropoff in older age groups (where retirement normally occurs). The highest rates for 9 of 14 major occupational categories occurred in the age intervals above 49 years of age. Sales workers and general laborers both experienced highest rates in the 30–39 age interval. In both instances, however, rates did not dropoff appreciably after reaching this peak. Observations for the farm laborers and foreman category were too small for meaningful analysis.

Academic students experienced their highest rate in the 20–29 age interval. However, the highest student rate was considerably below the total age-specific rate of 5.2. The retired, none, or unknown category also experienced a peak in the 30–39 age interval with a rather erratic pattern afterwards. The age distribution of this group (from raw data) clearly indicates that this category predominantly comprises "none" or "unknown" with a concentration seen in the younger ages and decreasing in higher ages.

TABLE 2.—General aviation accident rates by major occupational category and age—1974

Major Occupational Category	Age Interval							TOTAL
	Less than 20 years	20-29	30-39	40-49	50-59	60-69	70-Plus	
Professional and Technical	6.6	9.2	7.9	7.6	7.4	14.7	49.4	8.2
Managers and Administrators, Except Farm	2.3	3.9	5.0	6.9	6.2	14.0	6.2	5.7
Sales Workers	1.6	4.4	6.5	6.1	4.9	5.6	-	5.6
Clerical Workers	0.8	3.4	3.3	5.0	5.1	4.1	-	3.6
Craftsmen	0.7	2.6	3.9	4.7	5.3	8.0	-	3.5
Operatives	2.7	5.6	4.3	6.5	7.6	2.1	-	5.2
Laborers, Except Farm	6.2	2.4	7.4	4.9	5.5	-	-	4.4
Farmers and Farm Managers	6.2	11.6	9.1	7.6	12.4	9.9	49.4	9.9
Farm Laborers and Foremen	12.3	12.3	12.3	-	-	-	-	12.4
Service Workers	2.5	5.9	5.5	6.2	27.3	-	-	6.3
Government Employees (nec)	-	-	3.8	6.8	3.5	-	-	3.6
Housewives	-	2.5	3.9	2.7	7.5	-	-	3.7
Students (Academic)	2.6	3.8	2.4	-	-	-	-	3.2
Retired, None or Unknown	1.5	4.7	7.8	6.9	4.8	4.6	6.2	5.6
TOTAL	2.5	5.2	6.3	6.6	6.5	8.6	10.3	5.9

Rates were highest for the professional and technical and farmers and farm managers categories in all age intervals. Since these rates do not consider exposure, the influence of the professional pilot experience in the professional and technical major occupational category is apparent (Table 1 indicates a low "per unit of exposure" accident experience for professional pilots, but even low rates produced high absolute numeric experience when a high group exposure existed). The experience of the farmers and farm managers category was consistent with previous findings.

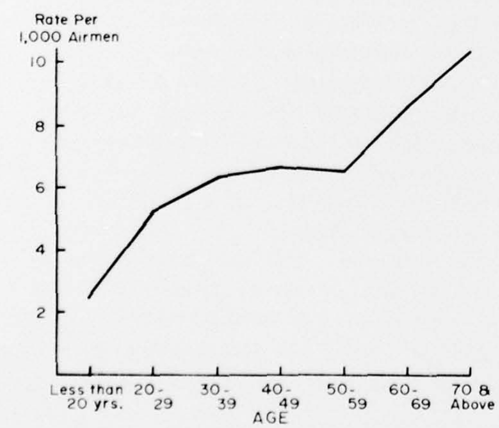

FIGURE 5.—General aviation accident rates by age—1974

D. *Accident Experience by Major Occupational Category and Cumulative Flight Time.* Requirements for the various airman ratings stipulate certain levels of cumulative flight experience, under various conditions, for minimum qualification. Thus, one assumes that a beneficial effect accrues with greater cumulative experience. However, at some point, cumulative flight experience ceases to be an asset and becomes a risk factor. As seen in the 1974 general aviation accident data presented in Table 3 and Figure 6, accident rates increase with cumulative exposure for all but the highest exposure category, where the drop is slight. Overconfidence and lack of vigilance by high-time pilots have been cited as possible contributors to this situation. Airline pilots, on the other hand, have the highest cumulative experience of any group but continue to have low accident rates. Airline pilots, as a rule, use more sophisticated equipment, both aircraft and navigational, and have professional help in performance of the flight task. Preflight planning and the flight routine are also likely to be more disciplined.

General aviation accident rates increase with an increase in cumulative flight experience within all major occupational categories and for the total population (an increase of 13–14 times from low to high cumulative categories). Highest rates are consistently in the greatest cumulative flight time intervals (see Table 3). Farmers and farm managers have among the highest rates regardless of exposure category. No other cate-

gory demonstrates such a pattern. Within the farmers and farm managers category, the pattern of increased rates with higher cumulative flight time is present but somewhat more erratic.

E. *Accident Experience by Major Occupational Category and Recent Flight Experience.* FAA regulations also require a minimum amount and type of recent flight experience for an airman to be current. Some minimum recent experience is thus considered necessary for the pilot to perform safely in the aviation environment. One might logically extend this argument to the conclusion that the greater the amount of recent experience one has, the safer he or she is as a pilot.

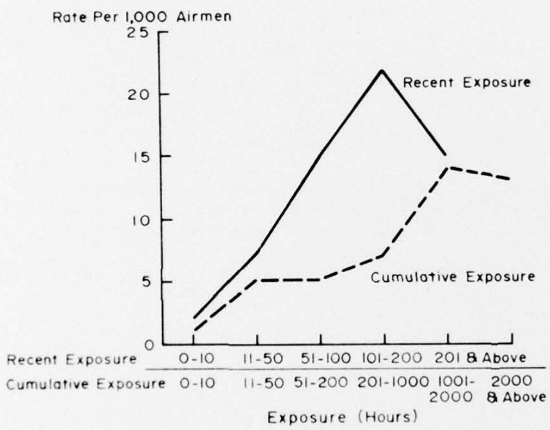

FIGURE 6.—General aviation accident rates by flight time—1974

However, the same patterns that are described for cumulative flight time emerge for recent flight time. Greater recent exposure to the general aviation flight environment results in higher risk, as shown in Table 4 and Figure 6. Overall and for all major occupational categories, rates increase with increased recent flight time. Overall, risk increases approximately 10 times from the 0–10 interval to the 101–200 interval. When flight time intervals are considered separately, farmers and farm managers again experience the highest rates in all but one interval. Some suggestion of a decrease in risk for the highest flight time interval is shown in the total rates.

F. *Accident Experience by Flight Experience and Age.* From the literature and preceding discussions, it appears that occupation, age, and flight experience are important variables with respect to the epidemiology of general aviation accidents. Exposure to the environment is obviously necessary to incur risk of accident. This fact is, and always has been, indisputable. It is the interrelationships of exposure with other variables that will provide additional information. Occupational and exposure relationships are presented in Tables 1, 3, and 4. Trends by occupation and age are apparent from data presented in Table 2. The relationship of age and exposure remain to be examined.

G. *Cumulative Flight Experience and Age.* The approximate fourteenfold increase from low to high cumulative flight time intervals for the total population has been previously noted. Likewise, the increase of approximately four

TABLE 3.—General aviation accident rates by major occupational category and cumulative flight time—1974

	Cumulative Flight Time (Hours)						
Major Occupational Category	0-10	11-50	51-200	201-1000	1001-2000	2001-Plus	Total
Professional and Technical	0.9	4.3	4.9	8.7	19.9	14.3	8.2
Managers and Administrators, Except Farm	1.5	6.8	5.8	5.9	9.2	10.4	5.7
Sales Workers	1.0	6.7	5.5	6.4	8.3	11.2	5.6
Clerical Workers	0.6	8.1	4.2	5.9	10.4	4.7	3.6
Craftsmen	0.6	2.7	4.2	5.8	12.7	9.9	3.5
Operatives	0.6	6.6	8.1	7.1	14.5	6.9	5.2
Laborers, Except Farm	0.9	4.1	6.0	7.0	5.3	16.5	4.4
Farmers and Farm Managers	2.5	12.4	10.1	9.9	20.1	15.1	9.9
Farm Laborers and Foremen	6.2	-	-	-	-	-	12.4
Service Workers	1.1	4.5	7.1	8.9	12.4	40.4	6.3
Government Employees (nec)	-	24.7	1.1	1.6	12.4	37.3	3.6
Housewives	1.4	10.5	4.7	2.5	-	-	3.7
Student (Academic)	0.7	6.3	4.9	8.7	21.7	16.5	3.2
Retired, None or Unknown	2.8	5.9	6.5	5.9	9.0	9.9	5.6
TOTAL	1.1	5.2	5.2	7.1	14.1	13.2	5.9

TABLE 4.—General aviation accident rates by major occupational category and recent flight experience—1974

Major Occupational Category	0-10	11-50	51-100	101-200	201-Plus	Total
	Recent Flight Time (Hours)					
Professional and Technical	2.3	8.2	15.6	20.7	14.4	8.2
Managers and Administrators, Except Farm	2.6	6.3	14.3	18.6	18.9	5.7
Sales Workers	2.0	6.6	22.3	26.6	66.1	5.6
Clerical Workers	1.7	6.5	8.9	24.8	-	3.6
Craftsmen	1.4	6.9	14.1	35.2	12.4	3.5
Operatives	2.4	8.3	20.7	15.5	-	5.2
Laborers, Except Farm	2.4	4.5	12.4	33.1	49.4	4.4
Farmers and Farm Managers	5.3	11.2	16.4	37.3	98.8	9.9
Farm Laborers and Foremen	-	-	-	-	-	12.4
Service Workers	2.3	8.4	41.4	21.3	16.0	6.3
Government Employees (nec)	1.4	5.5	6.2	-	12.3	3.6
Housewives	2.3	6.2	18.6	-	-	3.7
Student (Academic)	1.4	7.4	9.9	29.0	62.1	3.2
Retired, None or Unknown	3.3	6.4	12.0	20.3	12.8	5.6
TOTAL	2.2	7.3	15.0	21.9	15.0	5.9

*Last six months flight time.

TABLE 5.—General aviation accidents by cumulative experience and age—1974

AGE GROUP	0-10	11-50	51-200	201-1000	1001-2000	2001+	TOTAL
	Cumulative Experience (Hours)						
Less than 20 years							
Accidents	17	31	35	27	2	4	116
Non-accidents	31,395	6,896	6,006	1,181	-	157	45,633
Subtotal	31,412	6,927	6,041	1,208	-	161	45,749
Rate/1000	0.5	4.5	5.8	22.3	-	24.8	2.5
20-29							
Accidents	67	148	255	332	192	213	1,207
Non-accidents	93,606	32,795	54,435	32,691	6,976	8,325	228,827
Subtotal	93,673	32,943	54,690	33,023	7,168	8,538	230,034
Rate/1000	0.7	4.5	4.7	10.0	26.8	24.9	5.2
30-39							
Accidents	65	98	285	362	175	372	1,357
Non-accidents	51,805	19,555	52,874	53,925	10,215	26,288	214,663
Subtotal	51,870	19,653	53,159	54,287	10,390	26,660	216,020
Rate/1000	1.2	5.0	5.4	6.7	16.8	14.0	6.3
40-49							
Accidents	58	60	162	346	118	315	1,059
Non-accidents	30,871	7,108	28,351	55,713	10,917	25,781	158,741
Subtotal	30,929	7,168	28,513	56,059	11,035	26,096	159,800
Rate/1000	1.9	8.4	5.7	6.2	10.7	12.1	6.6
50-59							
Accidents	19	22	67	163	78	243	592
Non-accidents	10,854	3,119	13,142	27,786	10,071	24,887	89,859
Subtotal	10,873	3,141	13,209	27,949	10,149	25,130	90,451
Rate/1000	1.7	7.0	5.1	5.8	7.7	9.7	6.5
60-69							
Accidents	2	4	12	27	10	68	123
Non-accidents	1,206	399	713	4,483	2,084	5,248	14,133
Subtotal	1,208	403	725	4,510	2,094	5,316	14,256
Rate/1000	1.6	9.9	16.6	6.0	4.8	12.8	8.6
70 and above							
Accidents	-	2	4	4	2	8	20
Non-accidents	242	-	77	479	159	959	1,913
Subtotal	242	-	81	483	161	967	1,933
Rate/1000	-	-	49.7	8.3	12.4	8.3	10.3
Unknown Age Accidents	12	1	2	1	1	-	17
Total							
Accidents	240	366	822	1,262	578	1,223	4,491
Non-accidents	219,968	69,869	155,595	176,257	40,419	91,644	753,752
Subtotal	220,208	70,235	156,417	177,519	40,997	92,867	758,243
Rate/1000	1.1	5.2	5.2	7.1	14.1	13.2	5.9

NOTE: Row and column totals may not equal the sum of cell values due to rounding.

times in rates by age has also been discussed. When the cumulative exposure intervals in Table 5 are considered separately, some increase in accident experience with age is noted for low experience intervals. However, for the higher cumulative exposure intervals, younger ages have much higher rates. Large numbers of airmen in lower age groups at lower exposure intervals tend to weight the total rates and produce low overall rates for younger ages. Well over one-half of the airman population has cumulative experience of 200 hours or less while only one-third of the accidents were in this interval.

When the age intervals are considered separately, a pattern of increasing rates with increased exposure is clear for all age intervals through 50–59. The trend for age intervals 60 and above is not so clear, with higher rates occurring at lower exposure intervals.

For purposes of the current analysis, Table 5 has been partitioned into four quadrants, depicted by the heavy lines, to indicate distinct categories of age or exposure as well as various combinations of the variables. The ratio of accident rates (relative risk) has been computed for the several pertinent comparison possibilities. Results are summarized in Table 6.

High exposure is seen to produce highest risk when considered separately and when combined with younger ages. For higher ages, increased cumulative exposure does not appear to be so important.

TABLE 6.—Relative risks associated with cumulative experience and age

Risk Factor(s)	Relative Risk
High age only	1.2
High exposure only	3.1
High age, high exposure	1.4
High age, low exposure	0.8
Low age, high exposure	2.7
Low age, low exposure	0.3
Within low ages - high vs low exposure	3.4
Within high ages - high vs low exposure	1.6
Within high exposure - high vs low age	0.8
Within low exposure - high vs low age	1.6

*Relative risk is the ratio of accident rates among those with the characteristic to the accident rate of those without the characteristic, e.g.

$$\text{Relative Risk} = \frac{\text{accident rate among high age airmen}}{\text{accident rate among all other airmen}}$$

II. *Recent Flight Experience and Age.* Recent flight experience (during the 6 months prior to the accident or medical application) and age are considered jointly in Table 7. Rates increased tenfold from the lowest recent exposure intervals to the higher intervals for total population experience. Age relationships are the same as described previously (fourfold increase from low to high ages). Holding exposure constant by considering the intervals separately, one can observe that rates increase with age in the three lowest exposure intervals. For higher exposure intervals, rates are higher in younger ages. About 60 percent of the population indicates flight time during the last 6 months in the 0–10 hours interval. This group experiences about 20 percent of the accidents. Conversely, 33 percent of all accidents occur among approximately 11 percent of the population with the higher recent experience (100 hours or greater).

Table 7 has also been partitioned to allow for risk comparison within and between some pertinent risk categories. Results are presented in Table 8 along with comparable results for the cumulative experience analysis. High recent exposure and lower ages are again seen to increase risk of accident. The only additional conclusion reached from analysis of recent experience is the increased importance of recent high exposure among the higher age groups. Risk magnitudes are also higher, according to recent experience analysis.

Whether one considers total experience or recent experience, the importance of increased exposure is apparent. Furthermore, recent experience appears to be more important than cumulative experience as a risk factor, according to the present analysis.

Some accepted relationships of greater accident experience with age have been shown to be erroneous when exposure is added to the equation for risk determination.

Younger ages have been found to experience higher general aviation accident rates at both higher cumulative and recent experience levels. Although younger ages are broadly defined here, this finding is consistent with motor vehicle accident experience; however, an assumed causal factor in motor vehicle accidents is lack of ex-

TABLE 7.—General aviation accidents by recent experience and age—1974

Age Group	Recent Experience (Hours) 0-10	11-50	51-100	101-200	201+	Total
Less than 20 years						
Accidents	35	50	11	6	14	116
Non-accidents	37,257	6,474	1,842	75	-	45,633
Subtotal	37,292	6,524	1,853	81	-	45,749
Rate/1000	.9	7.7	5.9	74.5	-	2.5
20-29						
Accidents	261	299	169	164	314	1,207
Non-accidents	157,042	42,389	10,141	6,118	13,137	228,827
Subtotal	157,303	42,688	10,310	6,282	13,451	230,034
Rate/1000	1.6	7.0	16.4	26.1	23.3	5.2
30-39						
Accidents	275	361	217	217	287	1,357
Non-accidents	122,716	49,254	14,281	8,160	20,252	214,663
Subtotal	122,991	49,615	14,498	8,377	20,539	216,020
Rate/1000	2.2	7.3	15.0	25.9	14.0	6.3
40-49						
Accidents	222	335	203	138	161	1,059
Non-accidents	81,611	43,562	12,765	6,869	13,934	158,741
Subtotal	81,833	43,897	12,968	7,007	14,095	159,800
Rate/1000	2.7	7.6	15.6	19.7	11.4	6.6
50-59						
Accidents	123	178	125	84	82	592
Non-accidents	40,552	25,677	8,493	5,796	9,342	89,859
Subtotal	40,675	25,855	8,618	5,880	9,424	90,451
Rate/1000	3.0	6.9	14.5	14.3	8.7	6.5
60-69						
Accidents	31	39	22	16	15	123
Non-accidents	5,929	5,116	1,669	709	710	14,133
Subtotal	5,960	5,155	1,691	725	725	14,256
Rate/1000	5.2	7.6	13.0	22.1	20.7	8.6
70 and above						
Accidents	8	7	4	-	1	20
Non-accidents	878	718	157	161	-	1,913
Subtotal	886	725	161	161	-	1,933
Rate/1000	9.0	9.6	24.8	-	-	10.3
Unknown Age Accidents	17	-	-	-	-	17
Total						
Accidents	972	1,269	751	625	874	4,491
Non-accidents	445,968	173,190	49,347	27,888	57,359	753,752
Subtotal	446,940	174,459	50,098	28,513	58,233	758,243
Rate/1000	2.2	7.3	15.0	21.9	15.0	5.9

NOTE: Row and column totals may not equal the sum of cell values due to rounding.

TABLE 8.—Relative risks associated with recent and cumulative experience and age

Risk Factor	Relative Risk (Recent Experience)	Relative Risk (Cumulative Experience)
High age only	1.2	1.2
High exposure only	4.6	3.1
High age, high exposure	2.3	1.4
High age, low exposure	0.8	0.8
Low age, high exposure	4.4	2.7
Low age, low exposure	0.3	0.3
Within low age--high vs. low exposure	5.2	3.4
Within high age--high vs. low exposure	2.5	1.6
Within high exposure--high vs. low age	0.7	0.8
Within low exposure--high vs. low age	1.5	1.6

perience. Other factors characteristic of younger ages must be of importance for general aviation accidents.

I. *Some Characteristics of Accident-Involved Airmen.* Additional data of a descriptive nature concerning airmen involved in general aviation accidents during 1974 are as follows:

Females experienced significantly fewer accidents than expected (103 observed; 215 expected).

From data presented in Table 9 and Figure 7, the peak months for general aviation accidents are observed to be April through September, consistent with an increase in general aviation activity during these months.

TABLE 9.—Month of accident occurrence—1974 general aviation accidents

Month of Accident	Frequency	Percent
January	313	7.0
February	248	5.5
March	326	7.2
April	400	8.9
May	452	10.1
June	486	10.8
July	516	11.5
August	507	11.3
September	371	8.3
October	352	7.8
November	257	5.7
December	258	5.7
Invalid month code or unknown	5	0.1
TOTAL	4,491	100.0

Table 10 shows the geographic distribution of accidents. While State of occurrence is often different from State of pilot residence, it is clear that States with the largest pilot population experience the highest frequency of accidents; i.e., California, Texas, and Florida. However, according to proportional expectations, these States have experience that is about as would be expected. Alaska has four times the number of accidents expected. Weather and type of flying may be part of the reason for Alaska's increased accident experience. Arkansas, Idaho, Nevada, New Mexico, West Virginia, and Wyoming all have at least double the accident experience expected, for reasons that are not obvious. States with substantially less than expected accident experience (about one-half) include Connecticut, Illinois, Indiana, Maryland, New Jersey, Tennessee, and the District of Columbia.

The distribution of accidents by time of occurrence within the day is what would be expected (see Table 11 and Figure 8). No important differences in the distribution of accidents by time of day are observed when less serious accidents are compared with serious or fatal accidents.

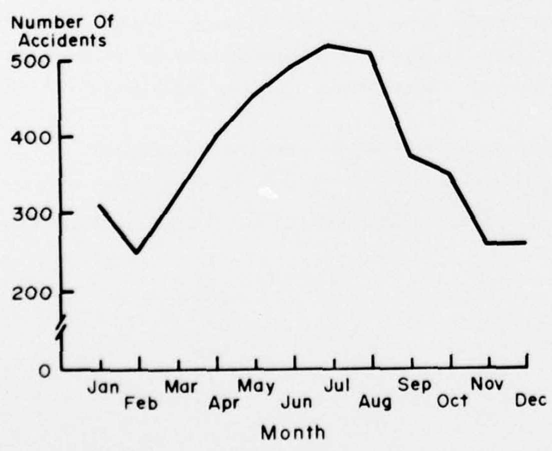

FIGURE 7.—Month of accident occurrence—1974 general aviation accidents

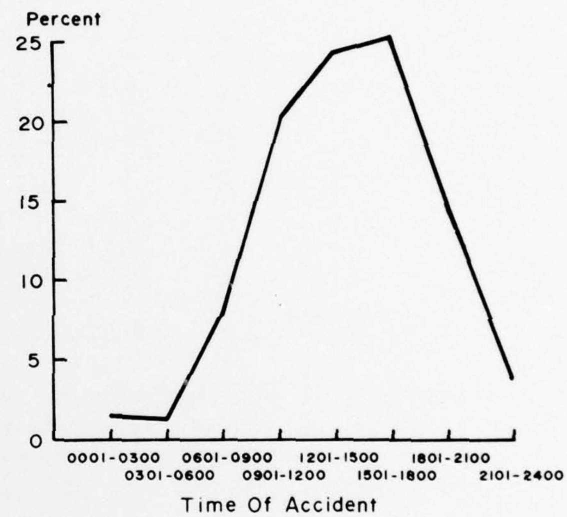

FIGURE 8.—Time of accident occurrence—1974 general aviation accidents

Table 12 and Figure 9 presents some interesting findings with respect to amount of exposure to the flight environment within the past 24 hours. Fifty-five percent of all accident-involved pilots had flown less than 1 hour in the past 24 hours. More fatal and serious accidents than less serious accidents occurred during the first hour of flight. Furthermore, almost half (48 percent) of the fatal and serious accidents occurred during the first half hour of flight. From these data, fatigue associated with long-duration flights does not appear to be a significant factor in the epidemiology of general aviation accidents.

TABLE 10.—State of accident occurrence by injury category of accident—1974 general aviation accidents

State	None	Minor	Serious	Fatal	Unknown	Total	Expected	O/E Ratio
	Degree of Injury							
Alabama	42	5	7	14	-	68	51.7	1.3
Alaska	145	21	17	24	-	207	50.5	4.1
Arizona	60	14	13	16	2	105	75.9	1.4
Arkansas	52	9	8	12	-	81	37.7	2.1
California	332	64	42	88	1	527	678.4	0.8
Colorado	72	20	9	25	-	126	91.8	1.4
Connecticut	12	4	5	4	1	26	61.8	0.4
Delaware	11	-	-	1	-	12	10.5	1.1
District of Columbia	1	1	-	-	-	2	5.5	0.4
Florida	161	27	20	31	1	240	255.3	0.9
Georgia	68	21	10	16	-	115	100.8	1.1
Hawaii	12	1	-	4	-	17	15.1	1.1
Idaho	42	7	5	11	-	65	28.3	2.3
Illinois	99	15	14	13	-	141	214.4	0.6
Indiana	37	9	7	11	-	64	108.8	0.6
Iowa	37	9	3	10	-	59	71.8	0.8
Kansas	53	8	12	12	-	85	82.5	1.0
Kentucky	20	14	2	6	-	42	36.8	1.1
Louisiana	56	12	8	7	-	83	58.3	1.4
Maine	16	10	5	6	-	37	19.4	1.9
Maryland	22	4	2	7	-	35	62.0	0.6
Massachusetts	41	11	9	6	-	67	82.5	0.8
Michigan	88	17	7	16	-	128	164.8	0.8
Minnesota	53	9	5	10	-	77	115.2	0.7
Mississippi	26	10	9	5	-	50	35.2	1.4
Missouri	46	6	11	17	-	80	103.6	0.8
Montana	44	3	6	4	-	57	30.0	1.9
Nebraska	57	5	2	5	-	69	45.0	1.5
Nevada	51	13	2	9	-	75	27.5	2.7
New Hampshire	11	2	2	2	-	17	21.9	0.8
New Jersey	45	10	6	9	-	70	115.4	0.6
New Mexico	46	12	6	14	-	78	35.1	2.2
New York	96	27	13	9	-	145	209.6	0.7
North Carolina	57	17	8	20	-	102	75.8	1.3
North Dakota	20	3	1	5	-	29	22.5	1.3
Ohio	91	25	8	17	-	141	199.3	0.7
Oklahoma	35	11	8	11	-	65	80.6	0.8
Oregon	45	10	7	11	-	73	71.7	1.0
Pennsylvania	100	15	7	18	-	140	146.8	0.9
Rhode Island	7	1	1	1	-	10	8.6	1.2
South Carolina	27	6	6	6	-	45	33.9	1.4
South Dakota	20	2	2	3	-	27	19.7	1.4
Tennessee	17	9	4	8	-	38	69.8	0.5
Texas	202	35	27	53	-	317	304.3	1.0
Utah	13	7	4	9	-	33	28.9	1.1
Vermont	6	2	1	1	-	10	9.7	1.0
Virginia	34	9	5	11	-	59	81.9	0.7
Washington	50	19	12	27	-	108	125.9	0.8
West Virginia	19	5	2	9	-	35	17.4	2.0
Wisconsin	52	8	8	13	-	81	78.1	1.0
Wyoming	23	7	3	5	-	38	13.0	2.9
Invalid State Codes or Unknown	54	3	10	17	6	90		
TOTAL	2,826	594	391	669	11	4,491		

The purpose of the flight resulting in the accident is recorded in Table 13. Approximately 40 percent of all accident flights were originated for business purposes and the remainder for pleasure.

Class of medical certificate and whether it contained any limitations of usage are presented in Table 14 for the accident-involved airmen. Slightly fewer-than-expected accident-involved airmen had limitations.

Within the agency, much interest has centered on frequency of examination and implied recency as a factor in reducing accident risk likely to result from medical factors. Table 15 and Figure 10 provide a breakdown of recency of medical examination among accident-involved

TABLE 11.—Time of accident occurrence by injury category of accident—1974 general aviation accidents

Time of Accident	None	Minor	Serious	Fatal	Unknown	Total	Percent
	Degree of Injury						
0001-0300	37	11	5	20	1	74	1.6
0301-0600	31	10	8	10	1	60	1.3
0601-0900	214	42	39	61	-	356	7.9
0901-1200	611	109	79	108	-	907	20.2
1201-1500	719	146	98	133	-	1,096	24.4
1501-1800	728	161	100	140	1	1,130	25.2
1801-2100	400	91	51	120	-	662	14.7
2101-2400	78	24	11	52	-	165	3.7
Invalid or Unknown	8	-	-	25	8	41	0.9
Total	2,826	594	391	669	11	4,491	100.0

TABLE 12.—Flight time in the 24 hours preceding accident occurrence by injury category of accident—1974 general aviation accidents

Flight Time Last 24 Hours	Degree of Injury None	Minor	Serious	Fatal	Unknown	Total	Cumulative Percent
Less than .5 hours	777	162	117	390	11	1,457	32.4
1	669	141	89	129	-	1,028	55.3
2	435	75	51	53	-	614	69.0
3	234	65	26	30	-	355	76.9
4	190	42	35	24	-	291	83.4
5	151	33	22	12	-	218	88.2
6	138	28	22	8	-	196	92.6
7	54	12	10	11	-	87	94.5
8	72	13	11	3	-	99	96.7
9	20	7	-	2	-	29	97.4
10	43	9	4	4	-	60	98.7
11	11	2	-	1	-	14	99.0
12	15	-	1	1	-	17	99.4
13	3	2	-	-	-	5	99.5
14	6	1	-	-	-	7	99.7
15	3	1	3	-	-	7	99.8
16	3	-	-	-	-	3	99.9
17	-	-	-	-	-	-	99.9
18	2	-	-	-	-	2	99.9
19	-	-	-	-	-	-	99.9
20 or more	-	1	-	1	-	2	100.0
Total	2,826	594	391	669	11	4,491	

airmen. It may be seen from Figure 10 that 42 percent of all accident-involved airmen had undergone medical examinations within 6 months prior to their accidents and 75 percent had undergone examinations within a year prior to their accidents. These data are difficult to interpret other than to observe that most accident-involved airmen had undergone fairly recent medical examinations. However, had the reverse situation been true, a stronger basis for hypothesizing medical factors causation would have existed.

TABLE 13.—Purpose of flight resulting in accident by injury category of accident—1974 general aviation accidents

Purpose of Flight	Degree of Injury None	Minor	Serious	Fatal	Unknown	Total
Business	1,191	223	173	237	1	1,825
Pleasure	1,635	371	218	432	10	2,666
Total	2,826	594	391	669	11	4,491

V. Conclusion and Summary

General aviation accidents obviously result from multiple causes. However, in applying the methods of epidemiology to this area, the assumption is not one of single causation but rather to search for a factor (or factors) with respect to the agent (aircraft), the host (pilot), or the environment, that can be controlled or mitigated to favorably influence accident incident or outcome.

Cockpit design has improved in recent years to increase the likelihood of accident survival. Agricultural accidents and resulting equipment are a prime example. Air traffic control and navigational equipment is constantly being scrutinized to improve the interface of the pilot with the environment.

Some other studies have been made to identify host-related factors that may have significant influence. Alcohol, drugs, medical factors, experience, and age are some variables that have been considered. Occupation, age, exposure, and their interrelationships have received considerable attention in this study in an attempt to better understand the etiology of general avia-

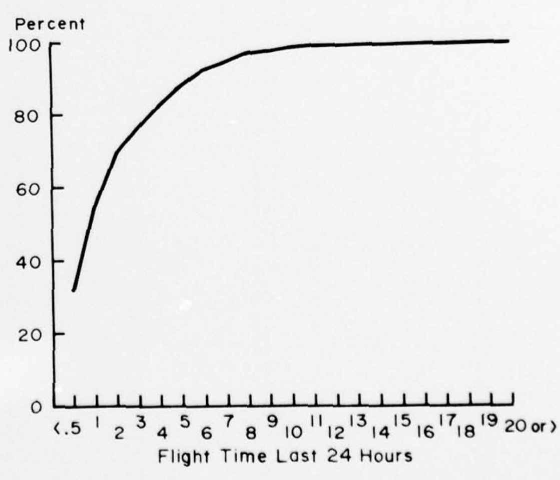

FIGURE 9.—Cumulative percent flight time last 24 hours—1974 general aviation accidents

TABLE 14—Medical certificate status of accident involved pilots—1974 general aviation accidents

Medical Certificate Status	Frequency
Class 1 medical, no limitations	384
Class 1 medical, with limitations	131
Class 2 medical, no limitations	1,386
Class 2 medical, with limitations	710
Class 3 medical, no limitations	1,079
Class 3 medical, with limitations	721
Not medically certified	5
Unknown	75
Total	4,491

Note: Of 4,491 accident airmen, 1,562 -- or 34.8 per 100 -- had limited medical certificates. Of 758,243 active airmen, 298,296 -- or 39.3 per 100 in the population -- had limited medical certificates.

$$\frac{\text{Observed}}{\text{Expected}} \text{ Ratio} = \frac{34.8}{39.3} = 0.88$$

tion accidents. Other descriptive characteristics of accident-involved airmen are also presented.

Occupation has been studied under assumptions of similar exposure, total cumulative exposure by occupation, and recent exposure by occupation with the outcome under at least two methods of analysis being the identification of physicians, lawyers, sales representatives, farmers, and housewives as having high accident experience.

This study also considered the relationship of occupation and age with respect to accident experience. The anticipated outcome of increased accident experience with age was observed for the total group and most of the major occupation categories.

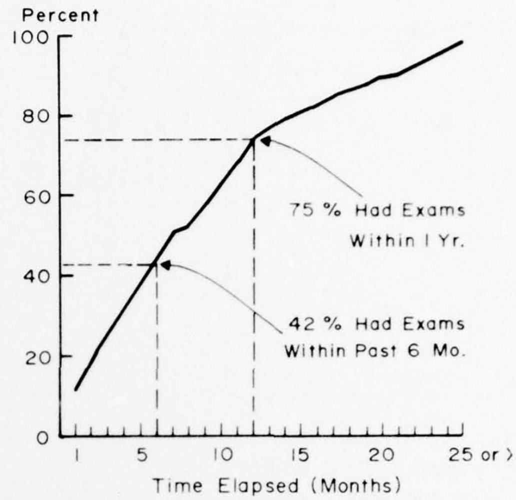

FIGURE 10.—Cumulative percent time elapsed since last medical examination—1974 general aviation accidents

When accident experience was examined by major occupational category and either cumulative or recent exposure, the outcome was one of increased risk with increased exposure, regardless of type.

TABLE 15.—Time elapsed since last medical by injury category of accident—1974 general aviation accidents

Time Elapsed (Months)	Degree of Injury					Total	Cumulative Percentage
	None	Minor	Serious	Fatal	Unknown		
1	352	70	42	50	-	514	11.4
2	220	45	32	29	-	326	18.7
3	185	30	26	53	-	294	25.2
4	160	37	20	42	-	259	31.0
5	176	41	21	34	1	273	37.1
6	170	36	18	25	-	249	42.6
7	133	25	23	28	-	209	50.7
8	130	29	22	35	-	216	52.1
9	147	39	18	33	-	237	57.4
10	149	35	22	34	-	240	62.7
11	159	33	19	34	1	246	68.2
12	181	30	23	51	-	285	74.5
13	83	11	8	22	-	124	77.3
14	59	11	10	20	-	100	79.5
15	48	10	2	17	-	77	81.2
16	42	16	6	12	-	76	82.9
17	57	10	4	14	-	85	84.8
18	33	12	5	10	-	60	86.2
19	50	7	9	12	-	78	87.9
20	42	10	5	13	-	70	89.5
21	39	5	8	11	-	63	90.1
22	39	10	12	8	-	69	92.4
23	46	12	9	18	-	85	94.3
24	48	13	7	17	-	85	96.2
25 and up	51	11	12	32	-	106	98.5
Invalid or Unknown	27	6	8	15	9	65	100.0
Total	2,826	594	391	669	11	4,491	100.0

In several previous studies, age has repeatedly been shown to be associated with increased risk of general aviation accidents. The exception, Mohler's 1967 study of accident experience by age,[30] concluded that the accident experience of older airmen was comparable to, and in some cases better than, that of their younger counterparts. However, a most important observation was made when exposure and age were jointly considered in this study.

Whether cumulative or recent exposure is considered, high exposure is associated with the highest risk, when considered separately and when combined with the younger ages. High exposure, in combination with or within any other comparison category, results in increased risk. Risk analyses, based on high age alone or in any combination not also associated with high exposure, are somewhat inconclusive. Whether cumulative or recent experience is considered, the importance of increased exposure is apparent. In addition, recent exposure appears to be more important as a risk factor.

The frequently observed relationships of greater risk of accident at higher ages is seen to result from a dilution of younger age rates by a large number in this age group with little or no exposure.

Exact mechanisms for the high risk associated with selected occupations and high-exposure younger age categories are subject to hypothetical conjecture. Certainly these areas deserve further study. Education, however, has proved to be a powerful tool in past health and safety efforts and should be utilized again, even in the absence of clearly established mechanisms.

Other descriptive findings for the accident-involved group are as follows: Females experienced significantly fewer accidents than expected. The months of April through September are peak accident months. Alaska, Arkansas, Idaho, Nevada, New Mexico, West Virginia, and Wyoming all had at least double the accident experience expected. Eighty-five percent of all accidents occurred between 9 o'clock in the morning and 9 o'clock in the evening. More than half of all accidents occurred within 1 hour after takeoff (55 percent). Sixty percent of accident flights were originated for pleasure purposes. Fewer-than-expected accident-involved airmen had medical limitations, and 75 percent had undergone medical examinations within a year prior to the accident.

REFERENCES

1. National Transportation Safety Board, Preliminary Estimates, May 1976, Washington, D.C.
2. Pott, P.: Chirurgical Observations Relative to the Cataract, the Polypus of the Nose, the Cencer of the Scrotum, etc., London, for L. Hawes, W. Clarke and R. Collins.
3. Seltser, R., and Sartwell, P. E.: The Influence of Occupational Exposure to Radiation on the Mortality of American Radiologists and Other Medical Specialists. AMERICAN JOURNAL OF EPIDEMIOLOGY, 81:2–22, 1965.
4. Castle, W. B., Drinker, K. R., and Drinker, C. K.: Necrosis of the Jaw in Workers Employed in Applyin a Luminous Paint Containing Radium. JOURNAL OF INDUSTRIAL HYGIENE, 7:371–382, 1925.
5. Case, R. A. M., Hosker, M. E., McDonald, D. B., and Pearson, J. T.: Tumours of the Urinary Bladder in Workmen Engaged in the Manufacture and Use of Certain Dye Stuff Intermediates in the British Chemical Industry. BRITISH JOURNAL OF INDUSTRIAL MEDICINE, 11:75–104, 1954.
6. Wagoner, J. K., Archer, V. E., Lundin, F. E., Jr., Holaday, D. A., and Lloyd, J. W.: Radiation as the Cause of Lung Cancer Among Uranium Miners. NEW ENGLAND JOURNAL OF MEDICINE, 273: 181–188, 1965.
7. Selikoff, I. J., and Hammond, E. C. (Ed.): Toxicity of Vinyl Chloride—Polyvinyl Chloride. Annals of New York Academy of Sciences 246:1–336, 1975.
8. Gardner, L. U.: Inhaled Silica and Its Effects on Normal and Tuberculous Lungs. JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION, 103: 743, 1934.
9. Kuh, C., and Ward, W. E.: Occupational Virus Hepatitis: An Apparent Hazard for Medical Personnel. JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION, 143:631–635, 1950.
10. Cobb, S., and Rose, R. M.: Hypertension, Peptic Ulcer, and Diabetes in Air Traffic Controllers. JOURNAL OF THE AMERICAN MEDICAL ASSOCIATION, 224, 4:489, 1973.
11. Friedman, M., Rosenman, R. H., and Carroll, V.: Changes in Serum Cholesterol and Blood Clotting Time in Men Subjected to Cyclic Variation of Occupational Stress. CIRCULATION, 17:852–861, 1958.
12. Hilleboe, H. E.: Public Health in the United States in the 1970's. AMERICAN JOURNAL OF PUBLIC HEALTH, Vol. 58, No. 9, 1968.
13. Wick, R. L.: The Relation of Aircraft Accidents to Occupation. FLYING PHYSICIAN, 3:10, 1966.
14. Zeller, A., and Mosely, H. G.: Aircraft Accidents as Related to Pilot Age and Experience. AVIATION MEDICINE, 171–79, 1957.
15. Zeller, A.: Age, Experience and Aircraft Accidents. AEROSPACE MEDICINE, 736–50, 1959.
16. Dougherty, J. D., et al.: Physical Defects of Civilian Pilots Related to Aircraft Accidents—A New Look at an Old Problem. AEROSPACE MEDICINE, 39: 521–7, 1968.
17. Rohde, C. A., and Ross, A.: Biostatistical Approach to the Epidemiology of Aircraft Accidents. Federal Aviation Administration Final Report Contract No. FA68WA–1966.
18. Yanowitch, R. E., Bergin, J. M., and Yanowitch, E. A.: The Aircraft as an Instrument of Self Destruction. FAA Office of Aviation Medicine Report No. AM–73–5, 1973.
19. Gibbons, H. L., et al.: Consideration of Volitional Acts in Aircraft Accident Investigation. AEROSPACE MEDICINE, 38:1057–9, 1967.
20. Mohler, S. R.: Recent Findings on the Impairment of Airmanship by Alcohol. FAA Office of Aviation Medicine Report No. AM–66–29, 1966.
21. Dille, J. R., and Mohler, S. R.: Drug and Toxic Hazards in General Aviation. FAA Office of Aviation Medicine Report No. AM–68–16, 1968.
22. Gibbons, H. L., et al.: Alcohol-Induced Hypoglycemia as a Factor in Aircraft Accidents. AEROSPACE MEDICINE, 37:959–61, 1966.
23. Smith, P. W., et al.: Toxicological Findings in Aircraft Accident Investigation. AEROSPACE MEDICINE, 41:760–2, 1970.
24. Alha, A. R., et al.: Detection of Alcohol in Aviation and Other Facilities in Finland. AEROSPACE MEDICINE 42:564–8, 1971.
25. Ryan, L. C., et al.: Intoxicating Liquor and the General Aviation Pilot in 1971. AEROSPACE MEDICINE,43:1024–6, 1972.
26. Harper, C. R., and Albers, W. R.: Alcohol and General Aviation Accidents. AEROSPACE MEDICINE, 35:462, 1964.
27. Costin, R.: General Aviation Accidents: An Epidemiologic Approach. Presented April 30, 1963, at the 34th Scientific Meeting, Aerospace Medical Association.
28. Harper, C.: Physical Defects of Civilian Pilots Related to Aircraft Accidents. AEROSPACE MEDICINE, 35:851, 1964.
29. Lategola, M. T., Fiorica, V., Booze, C. F. Jr., and Folk, E. D.: Comparison of Status Variables Among Accident and Non-Accident Airman from the Active Airman Population. FAA Office of Aviation Medicine Report No. AM–70–18. 1970.
30. Mohler, S. R., Bedell, R. H. S., Ross, A., and Veregge, E. J.: Aircraft Accidents by Older Persons. FAA Office of Aviation Medicine Report No. AM–67–22, 1967.
31. Ryan, G. A., et al.: Epidemiology of Aerial Application Accidents. AEROSPACE MEDICINE, 40:304–9, 1969.
32. Mohler, S. R., Freud, S. L. Veregee, J. E., and Umberger, E. L.: Phyician Flight Accidents. FAA Office of Aviation Medicine Report No. AM–66–25, 1966.
33. Wick, R. L., Jr.: Study of U.S. Physician Pilot Flying Habits. AEROSPACE MEDICINE, 39:1225–8, 1968.